

1 We Claim:

2  
*Sub A1*  
3 1. An electrotransport device for in vivo delivery of a charged agent  
4 through a body surface at a higher electrotransport agent delivery efficiency (E)  
5 defined by the agent delivery rate per unit of applied current; the device (10) having  
6 a donor reservoir (26, 46) containing the charged agent and having a delivery area,  
7 and having a source of electrical power (32) and a current controller (19, 40), the  
8 device (10) being characterized by:

9 the current controller (19, 40) being adapted to provide an applied pulsing  
10 current having a periodic current waveform, a pulsing frequency, and a duty cycle,  
11 the pulsing current applied to the reservoir (26, 46) and to the body surface, wherein  
12 an applied current density is defined by the applied pulsing current divided by the  
13 delivery area, and wherein the body surface exhibits a higher electrotransport agent  
14 delivery efficiency (E) when the applied current density is greater than or equal to a  
15 critical current density level ( $I_c$ ) and the applied pulsing current is applied for greater  
16 than or equal to a critical time period ( $t_c$ ).  
17

18 2. The device of claim 1, wherein the agent delivery efficiency (E) is more  
19 stable when the applied current density is above the critical level ( $I_c$ ) and less stable  
20 when the applied current density is below the critical level ( $I_c$ ).  
21

22 3. The device of claim 1, wherein the device (10) is adapted to be applied  
23 to intact human skin and the controller (19, 40) is adapted to provide an applied  
24 current density of at least about  $40 \mu\text{A}/\text{cm}^2$ .  
25

26 4. The device of claim 1, wherein the agent is fentanyl and the controller  
27 (19, 40) is adapted to provide an applied current density of at least about  $40 \mu\text{A}/\text{cm}^2$   
28 for at least about 10 msec.  
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1       5. The device of claim 1, wherein the agent is goserelin and the controller  
2 (19, 40) is adapted to vary and control the periodic current waveform to provide an  
3 applied current density of at least about  $50 \mu\text{A}/\text{cm}^2$  for at least about 10 msec.

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5       6. The device of claim 1, wherein  $t_c$  is at least 5 msec.

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7       7. The device of claim 1, wherein the periodic current waveform has a  
8 current magnitude that provides a second applied current density less than  $I_c$ .

9

10       8. The device of claim 7, wherein the second applied current density is  
11 approximately zero.

12

13       9. The device of claim 7, wherein the controller (19, 40) is adapted to  
14 vary the duty cycle and the agent delivery rate.

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16       10. The device of claim 7, wherein the controller (19, 40) is adapted to  
17 vary the frequency and the agent delivery rate.

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19       11. The device of claim 1, wherein the donor reservoir contains at least  
20 one suitable competitive specie.

21

22       12. The device of claim 1, wherein the controller (19, 40) is adapted to  
23 vary and control the frequency of the applied pulsing current to less than about 100  
24 Hz.

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26       13. The device of claim 1, wherein the controller (19, 40) is adapted to  
27 vary and control the frequency of the applied pulsing current to less than about 10  
28 Hz.

14. A method of in vivo delivery of a charged agent from an  
electrotransport delivery device (10) through a body surface at higher  
electrotransport agent delivery efficiency (E) defined by the agent delivery rate per  
unit of applied current; the device (10) having a donor reservoir (26, 46) containing  
the agent and having a delivery area, and having a source of electrical power (32)  
and a current controller (19, 40), the method being characterized by the steps of:

adapting the current controller (19, 40) to provide an applied pulsing current  
having a periodic current waveform, a pulsing frequency, and a duty cycle, the  
pulsing current applied to the reservoir (26, 46) and to the body surface, wherein an  
applied current density is defined by the applied pulsing current divided by the  
delivery area, and wherein the body surface exhibits a higher electrotransport agent  
delivery efficiency (E) when the applied current density is greater than or equal to a  
critical current density level ( $I_c$ ) and the applied pulsing current is applied for greater  
than or equal to a critical time period ( $t_c$ ).

15. The method of claim 14, wherein the agent delivery efficiency (E) is  
more stable at a current density above the critical level ( $I_c$ ) and less stable at a  
current density below the critical level ( $I_c$ ).

16. The method of claim 14, wherein the device is adapted to be applied to  
human skin, and the controller (19, 40) provides an applied current density at least  
about  $40 \mu\text{A}/\text{cm}^2$ .

17. The method of claim 14, wherein the agent is fentanyl, and the  
controller (19, 40) provides an applied current density of at least  $40 \mu\text{A}/\text{cm}^2$  for at  
least about 10 msec.

18. The method of claim 14, wherein the pulsing frequency is less than  
about 100 Hz.

AMENDED SHEET

1           19. The method of claim 14, wherein the pulsing frequency less than about  
2   10 Hz.

3

4           20. The method of claim 14, wherein the duty cycle is less than about  
5   100%.

6

7           21. The method of claim 14, wherein the body surface comprises intact  
8   human skin and  $I_c$  is at least about 40  $\mu\text{A}/\text{cm}^2$ .

9

10          22. The method of claim 14, wherein the agent is fentanyl, the body  
11   surface is intact human skin, and the applied pulsing current is equal to  $I_c$  which is at  
12   least about 40  $\mu\text{A}/\text{cm}^2$ , and wherein the pulsing current is applied for at least about  
13   10 msec.

14

15          23. The method of claim 14, wherein the agent is goserelin, and the  
16   applied pulsing current is at least about 50  $\mu\text{A}/\text{cm}^2$ , and wherein the pulsing current  
17   is applied for at least about 10 msec.

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19          24. The method of claim 14 further including the step of varying the duty  
20   cycle and the agent delivery rate.

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22          25. The method of claim 14 further including the step of varying the  
23   pulsing frequency and the agent delivery rate.

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25          26. The method of claim 14 further including the step of adding a suitable  
26   competitive specie to the donor reservoir (26, 46).